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Valuing ecosystem services

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Today society finds itself confronted with difficult trade-offs between some of its most important activities and ideals, in particular when it comes to allocation of natural capital and its associated services. In virtually any community, natural capital and its services are being allocated to various activities resulting in a widespread loss of such natural systems to agricultural, industrial and urban purposes. The extent of this appropriation was in 1986 as assessed in a landmark paper by Vitousek, Ehrlich, Ehrlich and Matson (1986), to be close to 40% of global net primary productivity (NPP).

The choice of whether and how to appropriate natural capital and its associated services in practice is reduced to the question of tradeoffs, where the aim is to chose the appropriation that will maximize net benefits. For example, should a farmer drain a wetland, with its associated economic benefits for the farmer, or should the wetland be allowed to persist and thereby maintain its multiple ecosystem services, such as carbon sequestration, hydrological and thermal buffering in addition to water filtration services to name a few. Economic agents involved in such allocation try to achieve the best (or most efficient) allocation of the wetland and when doing so consciously or unconsciously evaluate which option is most valuable economically to the nation, firm or the individual in the long run, as measured by social welfare, profits or utility, respectively.

This presents a practical dilemma for economic agents as many of the benefits derived from natural systems or natural capital are classified as non-market goods and services, and as such are external to the market. Consequently, such services remain external to formal decision-making processes resulting in their suboptimal allocation. This seems to imply that such benefits contribute little to profits, utility or economic welfare. However nothing could be further from the truth. As illustrated for example by the Millennium Ecosystem Assessment (MEA, 2005) and Costanza et al. (1997) among many others continued provision of those essential and valuable services is necessary for continued human well-being and economic prosperity. Therefore they must be properly accounted for. A failure to do so will result in suboptimal allocation of ecosystem services and potential depletion of natural capital stocks (Daly & Costanza, 1992).

This paper provides an introductory overview of the relationship between ecosystem services and human well being, with a particular focus on the services provided by the site chosen for the first ecosystem services study in Iceland, the Economic evaluation of ecosystem services: Heiðmörk.

The first section of the paper explains the concepts natural capital and ecosystem services. The second section provides an overview over the methods used when valuing ecosystem services. The last section introduces the first Icelandic ecosystem services research project.

Natural Capital and Ecosystem Services

What is natural capital and ecosystem services?

According to the first law of thermodynamics, energy and materials can neither be created nor destroyed. This implies a finite amount of materials on earth, continuous waste flows, reliance of human economies on materials from natural systems and absolute temporal limits on material use. As a result, human economies can be viewed as subsystems of nature, reliant on its continuous provisioning of goods and services such as material and energy flows.

Natural systems consist of what is called natural capital, which similar to man-made capital yields through its multiple functions a flow of goods and services into the future. Such goods and services, which provide direct or indirect benefits to humans, and thereby support human well-being, are collectively called ecosystem services (Daly & Costanza, 1992; MEA, 2005). The same natural capital can provide multiple services at the same time, yet tradeoffs occur between the provisioning of different ecosystem services. Since the flow of services requires proper maintenance of natural capital, the protection of natural capital is fundamentally important to ensure continued human and economic well-being (Costanza et al. 1997; MEA, 2005). Table 1, below, provides a list of various ecosystem services and their corresponding ecosystem functions.

Table 1. Examples of ecosystem functions and ecosystem services (from Costanza et al., 1997)

Ecosystem Goods and Services	Ecosystem Functions
Gas regulation	Regulation of atmospheric chemical composition
Climate regulation	Regulation of global temperature and precipitation and other biologically mediated dimatic processes at global or local levels
Disturbance regulation	Damping and integrity of ecosystem response to environmental fluctuations
Water regulation	Regulation of hydrological flows
Water supply	Storage and retention of water
Erosion control and sediment retention	Retention of soil within an ecosystem
Soil formation	Soil formation process
Nutrient cyding	Storage, internal cyding processing and acquisition of nutrients
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients and compounds
Pollination	Movement of floral gametes
Biological control	Trophic-dynamic regulation of populations
Refugia	Habitat for resident and transient populations
Food production	Proportion of gross primary productivity extractable as food
Raw materials	Proportion of gross primary productivity extractable as raw materials
Genetic resources	Sources of unique biological materials and products
Recreation	Providing opportunities for recreation activities
Cultural	Providing opportunities for non-commercial use

A forest is an example of such service-providing natural capital, and provides both direct and indirect benefits through various goods and services. Direct services include those that are easily defined such as fibers, timber or apples. They in many cases are exchanged in markets, have a market price and as a result quite frequently provide the value of the natural capital in question, as seen by decision-makers.

Indirect services include essential life-support services that are necessary for continued human wellbeing. These include services such as water filtration and regulation, air quality regulation, flood and erosion prevention, habitat for biodiversity

and climate regulation at various scales, in addition to essential waste assimilative services such as carbon sequestration. In addition, humans derive what is called cultural services from forests as they provide a place to socialize, play and exercise, a place to recuperate from stress, and a place to learn. Thus cultural services include educational, spiritual and recreational services in addition to existence benefits that capture the value derived from the forest simply due to its existence.

In this example, tradeoffs exist between indirect and direct services, as it is not possible to simultaneously extract timber benefits and life-support services such as water filtration or carbon sequestration from the same tree. In order to assess such tradeoffs, direct and indirect benefits must be internalized and compared by assessing their relative value by assigning a monetary value to the flow of benefits. The next section reviews the main methods used in the valuation of ecosystem services.

Valuing Ecosystem Services

Classifying Ecosystem Goods and Services

The term ecosystem services was originally designed to bridge the ecological and economic perspective of value by clearly illuminating that the structure and functions of ecosystems or natural capital provide benefits or value to humans (Daly & Costanza, 1992). Ecological/economic valuation begins by identifying for the capital in question, its key structures, functions and their derived services (see examples of functions and services in Table 1). The next step is to classify the various services. Various classification schemes have been devised for ecosystem services such as by Goulder and Kennedy, (1997), De Groot et al. (2002) and in the Millennium Ecosystem Assessment (MEA, 2005). One of the most commonly used classification scheme today is the one devised in the Millennium Ecosystem Assessment (MEA, 2005), which divides ecosystem services to four groups:

1. **Provisioning services**; are the products people obtain from ecosystems, including the food, wood, fresh water, fuel and genetic resources.
2. **Supporting services**; are those services necessary for the production of all other services, such as primary production and soil formation.
3. **Regulating services**; are the benefits people obtain from the regulation of ecosystem processes, including climate regulation, flood regulation, air quality maintenance, water purification, regulation of biogeochemical cycles such as the carbon cycle and erosion control.
4. **Cultural and amenity services**; are the nonmaterial benefits people obtain from ecosystems through cognitive development, reflection, recreation, spiritual enrichment and aesthetic experience.

Each groups contributes directly and indirectly to human wellbeing (MEA, 2005) but supporting and regulating services embody the services referred to above as life-support services.

Valuation

After ecosystem services have been identified, each service type is matched with appropriate valuation method. Broadly, economic values of ecosystem services are broken to use and non-use values. Use values include direct use, indirect use and option values. Direct use refers to the services that are used directly by human beings such as consumption of food or use of an ecosystem for recreation. Indirect use refers to benefits that are indirectly used such as maintaining air and water quality, carbon sequestration or primary production. Option values are derived from retaining the

capability to use ecosystem goods and services in the future, even if they are not currently used.

Non-use values are derived from the enjoyment people can experience from the knowledge that a natural environment exists and is maintained, and include bequest value, altruistic value and existence values.

The total value of the benefits derived from natural capital, is the sum of use and non-use values. Several methods exist to assess use and non-use value (see Freeman, 2003 for an overview of valuation methodology) and the most common ones, apart from using direct market prices, are briefly described below.

Use values

The travel cost method is based on using travel expenses as a proxy for the value of e.g. recreational services of a particular site. The underlying rationale is that travel is a complementary good to recreation for most individuals. A statistical relationship between observed visits and the cost of visiting is used to approximate a demand curve for visits to the site. Once a demand curve has been estimated, consumer surplus can be calculated as a measure of the welfare effect of the environmental service the visitor is seeking. The method has been widely used to estimate recreational value (Bowes & Krutilla, 1989). A survey of the method can be found in Flecher et al. (1990).

The hedonic pricing method is based on the theory of characteristics value, first proposed by Lancaster (1966) where the value of an ecosystem service is captured through the contribution of the service to the price of associated products such as housing. The approach has three stages. The first step involves the estimation of the hedonic price function. It is a function that describes the unit price of a commodity as a function of its characteristics. The second step involves calculating implicit characteristic prices as the derivative of the hedonic price function with respect to the ecosystem service of interest. The third step involves estimating the demand curve for the chosen service. Examples of applications of the hedonic pricing method include O' Bryne, Nelson and Seneca (1985) and Zabel and Kiel (2000). The value of Esjan was the subject of the only hedonic pricing study performed so far in Iceland (Sigurður Johannesson, 2003).

Net factor income or derived value method is based on estimating the contribution of the chosen ecosystem service to output such as tourism or fish yield, using a conventional production function. Examples include assessments of how much of the added value generated by tourism is attributable to the existence of a particular ecosystem, as opposed to other inputs such as produced capital, material inputs, and labor, or the contributing value of water quality to fish yield.

Preventive cost avoided, defensive expenditures and replacement cost, involve estimating the value of ecosystem services based on the costs of avoiding damages due to lost services, the cost incurred due to necessary purchases due to lost services and the cost of replacing ecosystem services. These methods do not provide strict measures of economic value. Instead, they assume e.g. that the cost of avoiding damages or replacing ecosystems and thus their services; provide useful estimates of economic value. This is based on the assumption that if people incur costs to avoid damages caused by lost ecosystem services then those services must be worth at least what people paid to avoid the damage. Consequently, those methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be made, or where perfect substitutes can be found.

Non-use values

The contingent valuation (CV) method is a survey-based technique for eliciting stated preferences for non-marketed goods, and is the most commonly used method

to assess non-use values. A CV is conducted by asking a sample of the affected population questions on well-specified hypothetical scenarios to identify the preferences of each respondent with respect to a defined environment. The key part of any CV study is the description of the scenario, the hypothetically planned change in environmental quality, and the question eliciting the individual respondent's willingness to pay (WTP) or willingness to accept compensation (WTA) for set change. This enables the estimation of an environmental service demand function. The CV methodology is well known and is extensively described in numerous textbooks in environmental economics (e.g. Bateman & Willis, 1999; Hanley & Spash, 1993). Rigorous guidelines on the implementation of CV's were given in the NOAA panel report (Arrow et al., 1993). Three CV studies have been performed in Iceland (Sigríður Ágústa Ásgrímsdóttir, 1998; Bothe, 2003; Lienhoop & MacMillan, 2007). Sigríður Ágústa Ásgrímsdóttir assessed the value of an area proposed for a hydroelectric project in Skagafjörður. Bothe (2003) assessed the willingness to prevent the potential environmental impact of the Kárahnjukar hydroelectric dam and Lienhoop and Macmillan (2007) assessed the willingness to pay and the willingness to accept payment for environmental impact due to the Kárahnjukar hydroelectric dam.

As can be seen from this short overview, valuation of ecosystem services was until recently largely an unexplored subject in Iceland and as a result the concept ecosystem services has not yet been used in environmental and resource management in the country. To change course in this regard, the first comprehensive ecosystem services research project in Iceland was initiated with the aim to assess the ecosystem services derived from Heiðmörk, a popular recreational area at the outskirts of the Icelandic capital area. The next section provides an overview over the study, but subsequent chapters describe individual study components.

Estimating the Value of Ecosystem Services: the Heiðmörk project

Introduction

The first research project on ecosystem services in Iceland is a multi-year, multi partner project. The partners include The University of Iceland, University of Vermont, The Agricultural College, Icelandic Forest Service, Reykjavik Forest Society, The Institute of Freshwater Fisheries, Reykjavik Energy, The city of Reykjavik and Gardabær municipality.

The overall objective is to provide the first comprehensive evaluation study for ecosystem services in Iceland, which can serve as a benchmark for future studies. It is expected to lay the foundation for classification of ecosystem services in Iceland, to build capacity in applying appropriate valuation methods for each service and thereby enable the use of the term in economic decision-making. Finally, it is intended to increase awareness of the importance of the multiple services we derive from natural capital, and thereby enrich the national discourse on resource use by swaying the discussion away from the conventional one-dimensional view of nature.

The Site

When selecting an appropriate site for a comprehensive ecosystem evaluation study that fulfills those aims, several criteria must be fulfilled. The most important criteria are (1) system boundaries must be clearly identifiable (2) the system must be diverse and multifunctional and thus provide a variation of different ecosystem goods and services (3) the geology and the ecology of the system must be somewhat known such to provide a solid foundation for the valuation study. Our chosen study site, Heiðmörk, fulfilled all those criteria.

Heiðmörk is an extensive, yet clearly defined nature reserve, bordering Reykjavík, Garðabær and Kópavogur. It encompasses around 3500 hectares of forests, lava fields, lakes and open areas. Use of Heiðmörk as a source of drinking water for the capital area started as early as 1909 from the Gvendarbrunnar Wells. In 1949 Heiðmörk was gazette as a nature reserve and recreational area. Later the area was extended to its current size.

The area provides an outstanding example of a multifunctional ecosystem, where a range of services can be identified. Some of the obvious services the Heiðmörk ecosystem provides can be identified as drinking water and recreational services. The area is a key water supply area for the Great Reykjavík area, harboring the Gvendarbrunnar wells that supply drinking water to more than half of the Icelandic population. Also, the area is a widely popular recreational area with accessible forests, lakes and open spaces, attracting over 500,000 visitors the year around. Other less obvious services are educational and cultural, carbon sequestration services and habitat services for various bird and fish species. Finally, the area provides the outer range/backdrop sheltering the capital settlement areas.

Being in such close vicinity to the Capital area also poses challenges, such as those relating to urban expansion and land disputes. A range of actors has a stake in Heiðmörk. Heiðmörk is currently the property of the city of Reykjavík, Garðabær and Reykjavík Energy. Land tenure is therefore communal, historically aimed at multi-functionality and collective use. Reykjavík Energy is responsible for the management of the drinking water resources, while the Reykjavík Forest Society has the mandate to manage the forests and recreational services. Further, the area is highly popular recreational area where many user groups such as fishermen, horse riders, hikers etc. can be identified as important stakeholders. Management of Heiðmörk is therefore a demanding multi-stakeholder exercise, where different tradeoffs, involving the value of different services need to be addressed simultaneously.

Identifying and valuing ecosystem services in Heiðmörk

Heiðmörk provides a specific set of ecosystem services, of which we chose to focus on a selected set of services, defined by identifiable system components. Within each system component the MEA classification scheme was used to define individual services, and then state-of-the-art valuation methods were used to value the identified ecosystem goods and services.

The system components and its associated services are as follows:

- The Water Catchment Area; which has a water supply function, as the area is an important catchment area for Reykjavik, providing clean drinking water and thereby providing provisioning services. To assess the value of the water provisioning services two separate valuation methods were used: replacement cost and cash flow analysis. A subsequent chapter in this issue describes this analysis (Hildur Sigurðardottir & Daði Már Kristófersson, 2010).
- The Forest and Vegetation; which provides multiple services such as: (a) provisioning services such as timber, Christmas trees, medicinal herbs, mushrooms and berries (b) support and regulating services such as carbon sequestration services and water filtration and (c) cultural and amenity services such as recreation. Cultural and amenity services are assessed as their own component of the study (see below), and water filtration services were evaluated as part of the water catchment component. As a result the forest component involves two parts: provisioning services and support services with a sole focus on carbon sequestration at this time (Pick, 2009).

- The lakes Elliðavatn/Vífilstaðavatn; which provide (a) provisioning services such as fish harvest as well as serving as a reservoir for a hydro-power plant, (b) supporting services such as maintenance of nutrition for Elliadar river (c) regulating services such as pollution dilution for the surrounding habited areas in addition to (d) cultural services such as education and recreation. In order to prevent double counting the value of fish harvest was excluded from the assessment, as most fish in the lakes for recreation purposes. A subsequent chapter in this issue describes this analysis (Halla M. Johannesdottir, 2010).

Due to the nature of the area, specific services transcend each system component and thus to prevent double counting those are identified as specific cross-cutting system components and assessed separately. Those-cross-cutting system components are:

- Recreational services. A series of travel cost surveys were conducted from the summer of 2008 to the end of September 2009, to capture this value. In addition, measurements of traffic flow were captured in cooperation with the Icelandic Road Authority. A subsequent chapter in this issue describes this analysis (Daði Már Kristófersson & Kristín Eiriksdottir, 2010).
- Cultural services as captured by existence value. The valuation of this component is perfumed using contingent valuation surveys. The survey was designed in 2009, implemented in 2010 and the results are currently being analyzed. The results derived from the CV assessment will support the results found in other components of the assessment.
- Bio- (e.g. plant and animal species), and geodiversity in the area in addition to heritage value is also included. The cultural and recreational value of those services is assessed in the study components described above. However careful inventory assessment of those components was conducted as well.

Conclusion

Data collection in the Heiðmörk project has been completed, and the study is quickly moving through its analysis phase. However, the project is already fulfilling its objective. Awareness of the importance of ecosystem services has increased in Iceland, and its incorporation into national and local decision-making has been proposed. Multiple young scholars have been introduced to the valuation methodology and interest is the valuation of ecosystem services is mounting.

Yet more work needs to be done, as assessing of the value of ecosystem services and the potential impact of planned projects on the provisioning of such services must become a routine part of any project appraisal.

Three additional papers in this volume will describe three separate components of the Heiðmörk ecosystem services project.

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